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Emerging Markets Queries in Finance and Business

Efficiency Progress and Productivity Change in Romania Machinery Industry 2001 – 2010

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Abstract

Machinery industry is an important economic key in Romania. In the period 2001-2010 the industry was faced with significant inputs of foreign direct investments that have led to stimulating the development of the economy. This paper examines the efficiency and productivity of enterprises (more than 250 employees) in machinery industry which are part of a emerging markets. In the machinery industry there are companies that deal with the cars manufacture, machinery and equipment and the manufacture of motor vehicles and their components. Techniques selected for evaluation of progress efficiency and changing productivity studied are Data Envelopment Analysis (DEA) and the Malmquist productivity index (MPI). This methodology allows a direct comparison between firms within the same industry and shows how intense inputs are used in a production system from which we want to realize a high level of output. The used program to calculate indicators of productivity and efficiency frontier was DEAP 2.1. (Data Envelopment Analysis Computer) developed by the Centre for Efficiency and Productivity Analysis of the University of New England. Analysis of positive or negative trends in the efficiency and productivity of enterprises in the studied period reveals information about the sources of existing inefficient. This paper is mainly aimed at measuring the technical efficiency and productivity change in the machinery industry in Romania between 2001-2010 and as secondary objective to determine the inefficient sources in industry. The results of the study show that the tendency of growth of total factor productivity (TFP) is due in particular to the efficiency progress and not to the technological change, what demonstrates that human resource quality has had a positive impact on the industry. Productivity is viewed as a competitive advantage, so companies that have increased productivity, even in a time of crisis, are based on modern management and performance.

Keywords: Efficiency; Productivity; Malmquist index; DEA; Machinery Industry

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1. Introduction

Machinery industry is considered the main branch of manufacturing industry and increasing labor productivity within it leads to economic development of human society. In Romania, machinery industry has an important role to increase export competitiveness which can be achieved by formulating strategies that increase productivity and reduce costs. Romania's foreign trade provides a relevant image of the industry competitivenessbeing the sector in economy with the largest contributionto external economic exchanges, according to the Ministry of Economy, Trade and Business Environment.

Efficiency, productivity and productive performance includes a wide range of issues essential to the smooth running of things in an activity, organization of a country and smooth running of things in the world. This research focuses on analyzing the efficiency and productivity, because is one of the methods used by decision units worldwide to measure performance in terms of inputs and outputs within them. Thus, the highest values of efficiency and productivity indicate a high level of performance. Increasing productivity is a key source of rising living standards in that there are more added values in production, an aspect that leads to an increase in disposable income. Achieving high productivity is related to the technical level of production and the level of development of the workforce. Determination of the level of efficiency and productivity in organizations is a current issue that puts great emphasis in both developed and developing countries around the world.

All enterprises, regardless of the industry of which they are part, are in a continuous process of self-evaluation, and for this they are permanently looking for instruments for measurement of the performance which fit better the areas to which they belong. In general, the instruments most commonly used to measure performance are the indicators which measure effectiveness and productivity. An indicator very used is total productivity of the factors (TFP), indicator which includes both partial productivity, such as labor productivity, as well as multi-factorial productivity that characterizes the level of an industry. Finding the level of productivity, its growth rate and productivity determinant factors that help to evaluate the efficiency of resource use within the industry, is a more intense concern for the economists (Ray, 2012). TFP is an important indicator for measuring changes in technology, measuring real output growth, which is not explained by changes in the input such as labor, capital and others. Dealing with some of the issues regarding efficiency and productivity are to be found in the works carried out by Camanho and Dyson 2006, Armagan et al. 2008, Dragomir et al. 2010, Azizi and Jahed 2011, Chou et al. 2012, Ray 2012, Lv et al. 2012,

The development of machinery industry was made visible along with the emergence of direct foreign investments and multinational companies who have opened branch offices in this country. So the level of development of the economy has increased noticeably in the first part of the survey period, having a level of growth moderated in the second half of the period, due to the world economic crisis. The speed with which advances science and the rising demands of their clients require enterprises from all industries to change or improve their technology more often in order to be able to raise productivity. Another important aspect of this problem is related to human resources in enterprises, resources that require constant development and motivation, and that decisively affect productivity and therefore business performance. Machinery industry is one of the industries that have to satisfy a wide range of needs about safety, quality, price, and also must have high productivity to achieve performance.

2. Measuring Efficiency and Productivity

Efficiency of decision-making units can be measured taking into account frontier production technology and a given level of output and input price. In this context, the decision is likely to be locative technical effective and efficient, but scale of operation could not be an appropriate one. In this case, you can improve efficiency of the scale for the company-wide to be effective. A unit that has a technology-based production with constant efficiency on a global scale, it is effective at the scale automatically. Efficiency at the scale is a simple concept and easy to understand in the case of a single input and a single output, but it is more difficult to understand in the case of multiple-input and multiple-output.

The concept of productivity is commonly defined as a ratio of the volume measure of output to the volume measure of input used, whereas efficiency is a relative concept, i.e. the performance of a firm is compared to a reference point. While there is no disagreement on this general notion, there are many different purposes for, and several distinct measures of, economic performance in the econometrics literature (OECD, 2001).

Measuring productivity and productivity change can be seen as part of decision-making performance measurement unit. Productivity is essentially a level concept and productivity measures can be used to compare performance of decision units, at some point of time. Productivity changes relate to movements of productive performance within a company or an industry over a long period of time.

2.1. The mathematical programming approach to efficiency measurement

The mathematical programming approach to the construction of frontiers and the measurement of efficiency relative to the constructed frontiers goes by the descriptive title data envelopment analysis (DEA). The aim of DEA is to estimate relative efficiency among similar decision units that have the same technology (processing procedure) to pursue similar objectives (outputs) by using similar resources (inputs). The higher efficiency is denoted by one, while the lowest is denoted by zero. DEA constructs the production-possibilities frontier with the help of linear programming data. The approach maps out a production frontier based on information on inputs and outputs. The degree of (in) efficiency is assessed by the distance between the observation and the frontier. The strength of the DEA approach is that no a priori structural assumption is placed on the production process. Since DEA in its present form was first introduced in 1978 of Charnes et al., researchers in a number of fields have quickly recognized that it is an excellent and easily used methodology for modeling operational processes for performance evaluations. The efficiency of a firm, or a decision making unit (DMU) as firms are called in most DEA literature, using *n* different inputs to produce *m* outputs, is measured as the ratio between the weighted outputs and weighted inputs.

Taking into consideration that suitable panel data are available, we can calculate the required distance using DEA linear method. For the *i*-th firm, it must be calculate four distance functions to measure the total factor productivity TFP change between two periods. This requires the solving of four linear programming LP problems:

$$
\begin{aligned}
& D_0^t(x^{t+1}, y^{t+1})^{-1} = \max_{\phi,\lambda} \Phi \\
\text{st -} \quad & \phi y^{it+1} + Y^t\lambda \geq 0, \\
& x^{it+1} - X^t\lambda \geq 0, \\
& \lambda \geq 0
\end{aligned}
\tag{1}
$$

$$
\begin{aligned}
& D_0^{t+1}(x^t, y^t)^{-1} = \max_{\phi,\lambda} \Phi \\
\text{st -} \quad & \phi y^{it} + Y^{t+1}\lambda \geq 0, \\
& x^{it} - X^{t+1}\lambda \geq 0, \\
& \lambda \geq 0
\end{aligned}
\tag{2}
$$

In relations (1) and (2), where production point are compared to technologies from different time periods, the ϕ parameter needs to be greater than or equal with one, as it must calculate the output-orientated technical efficiencies. The data point could lie above the feasible production set. This will most likely occur in relation (2) where a production point from period *t* is compared to technology in an earlier period, *t+1*. If technical progress has occurred, then a value of $\phi \geq 1$ is possible. It could also possibly occur in relation (1) if technical regress has occurred, but this is less likely.

2.2. Malmquist productivity index

Numerical indices to measure individual and aggregate consumption were proposed by Malmquist (1953). These indices are used in the context of measuring productivity. Malmquist productivity indices were used for the first time in two influential works by Caves et al. 1982a, 1982b. In this work the authors have defined the TFP index using distance functions Malmquist input and output, and since this index is known as "Malmquist productivity index (MPI)". This index is constructed by measuring radial distance vector of output and input, note in the time periods *t* and *t+1*, relative to a given technology. These distances can be oriented towards the exit or entry, and MPI differ depending on the orientation used.MPI is defined using non-parametric distance functions, which determine the distance of a firm from its optimal production given the observed output and applied input. MPI can decompose the productivity growth into two mutually exclusive components: technical efficiency change and technical change overtime, which measures the change in efficiency frontier shift, respectively. These are: (1) technical efficiency change (EFFTH); (2) technological change (TECHCH); (3) pure technical efficiency change (PECH); (4) scale efficiency change (SECH); (5) total factor productivity change (TFPCH) Azizi et al. 2011. We start by considering firms which use *n* inputs to produce *m* output. Denote $x \in R_+^n$ and $x \in R_+^n$ as, respectively, the input vector and output vector of those firms. Then, the output distance function at time *t* can be defined on the technology $P^t = \{(x^t, y^t) : x^t, \text{can produce } y^t\}$ as:

$$D_0^t(x^t, y^t) = \inf\{\theta : (x^t, y^t/\theta) \in P^t\} \tag{3}$$

The distance function is defined as the reciprocal of the maximum proportional expansion of the outputs vector y^t, given the level of inputs x^t, so that the new observation $(x^t, y^t/\theta)$ is at the frontier of period *t*. This function characterizes completely the technology in such a way that $D_0^t(x^t, y^t) \leq 1$: if and only if $(x^t, y^t) \in P^t$. Furthermore, $D_0^t(x^t, y^t) = 1$ if and only if the observation stands at the limits of the frontier, which occurs when the observation is efficient (Chen, 2012). The Malmquist productivity index (MPI) is defined as the geometric mean of two distance-function-based Malmquist productivity indices, so it is possible to break it down into the following catching-up effect and technical change:

$$M_0(x^t, y^t, x^{t+1}, y^{t+1}) = \Delta TE(x^t, y^t, x^{t+1}, y^{t+1})\left[\Delta T(x^t, y^t) \cdot \Delta T(x^{t+1}, y^{t+1})\right]^{1/2} \tag{4}$$

MPI components can be taken as independent elements that can be expressed mathematically with the relationships:

$$\Delta T(x^t, y^t) = \left[\frac{D_0^t(x^t, y^t)}{D_0^{t+1}(x^t, y^t)}\right] \tag{5}$$

$$\Delta T(x^{t+1}, y^{t+1}) = \left[\frac{D_0^t(x^{t+1}, y^{t+1})}{D_0^{t+1}(x^{t+1}, y^{t+1})}\right] \tag{6}$$

$$\Delta TE(x^t, y^t, x^{t+1}, y^{t+1}) = \left[\frac{D_0^{t+1}(x^{t+1}, y^{t+1})}{D_0^t(x^t, y^t)} \right] \quad (7)$$

The leading ratio of D_0^{t+1} to D_0^t outside the square root is equivalent to the change in technical efficiency between periods *t* and *t+1*. This ratio represents the change in the relative distances from the observed output to the potential maximum output at time *t* and *t+1*. On the other hand, the parts inside the square root represent technical change. We note that the output distance function D_0^t represents the level of observed outputs relative to maximum outputs by using the production technology available at time *t*. Thus, technical change is calculated as the geometric mean of the shift in the production frontier from time t to *t+1*. The first component inside the square root is the shift in the production frontier evaluated at x^{t+1} and y^{t+1} relative to the maximum outputs specified by the production technology available at time *t* and *t+1*, respectively. Similarly, the second component is the shift in the production frontier evaluated at x^t and y^t relative to the maximum outputs specified by the production technology available at time *t* and *t+1*.

3. Research Results

In the present research was taken into account a batch of 27 enterprises whose activity is carried out within the machinery industry of Romania. In the machinery industry there are companies that deal with the cars manufacture, machinery and equipment and the manufacture of motor vehicles and their components. Out of a total of 87 large enterprises with more than 250 employees, working in the machinery industry in Romania for more than 10 years, the group studied represents a substantial proportion of 31%.Techniques selected for evaluation of progress efficiency and changing productivity studied are Data Envelopment Analysis (DEA) and the Malmquist productivity index (MPI). This methodology allows a direct comparison between firms within the same industry and shows how intense inputs are used in a production system from which we want to realize a high level of output. The used program to calculate indicators of productivity and efficiency frontier was DEAP 2.1. (Data Envelopment Analysis Computer) developed by the Centre for Efficiency and Productivity Analysis of the University of New England. To provide an overview, presenting data in machinery industry in Romania on efficiency progress and productivity change in the period 2001-2010 was released on the 7 geographical areas of the country: area of N-E, area of S-E, area of S, area of S-V, area of V, area of N-V and area of Center (Table 1. and Table 2.).

Table 1.Efficiency progress VRS

Area of Romania	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
1. N-E	0.666	0.366	1.000	1.000	0.480	0.946	1.000	1.000	0.982	0.993
2. S-E	1.000	1.000	1.000	1.000	1.000	0.865	1.000	1.000	1.000	1.000
3. S	1.000	1.000	1.000	1.000	0.685	0.993	0.747	0.500	1.000	1.000
4. S-V	0.039	0.045	0.106	0.091	0.155	0.202	1.000	0.183	0.158	0.299
5. V	1.000	0.999	0.947	1.000	1.000	1.000	1.000	1.000	1.000	1.000
6. N-V	1.000	0.346	0.517	0.477	0.587	0.554	0.681	0.329	0.466	0.500
7. Center	0.404	0.164	1.000	0.716	1.000	1.000	1.000	1.000	1.000	1.000
Mean	0.730	0.560	0.796	0.755	0.701	0.794	0.918	0.716	0.801	0.827

Technical efficiency values of the years 2001-2010 are presented in Table 1. To interpret the resulting data are necessary that the following to be specified: values higher than one indicates an excessive use of inputs, making possible to improve productivity by reducing inputs. Value one show a constant productivity level in the studied period. Subunit values indicate a rational use of inputs (conservation inputs) highlighting increased productivity in relation to inputs.

Table 2.Malmquist index summary of area means

Area of Romania	EFFCH	TECHCH	PECH	SECH	TFPCH
1. N-E	0.925	1.080	1.045	0.884	0.999
2. S-E	0.913	1.080	1.000	0.913	0.986
3. S	1.500	1.080	1.106	1.357	1.620
4. S-V	0.663	1.080	0.926	0.716	0.716
5. V	0.794	1.080	1.000	0.794	0.858
6. N-V	1.065	1.080	1.253	0.850	1.150
7. Center	0. 862	1.080	1.000	0.862	0.931
Mean	0.932	1.080	1.043	0.894	1.007

According to data obtained from Malmquist index calculation it is to be noted that machinery industry recorded the largest increase efficiency and productivity in the S area of Romania, followed by the N-V area.

Table 3.Malmquist index summary of annual means

Year	EFFCH	TECHCH	PECH	SECH	TFPCH
2002	3.192	0.303	0.706	4.518	0.968
2003	0.344	3.945	1.776	0.194	1.357
2004	0.365	2.838	0.929	0.393	1.036
2005	1.863	0.309	0.994	1.874	0.575
2006	2.253	0.482	1.173	1.921	1.086
2007	6.642	0.103	1.278	5.195	0.683
2008	0.215	5.424	0.668	0.322	1.167
2009	0.525	2.503	1.133	0.463	1.313
2010	0.421	2.831	1.109	0.380	1.192
Mean	0.932	1.080	1.043	0.894	1.007

Was calculated Malmquist total factor productivity and efficiency change, technical change for all the years in the sample? A summary description of the average performance of the machinery industry over the entire period is presented in Table 3.

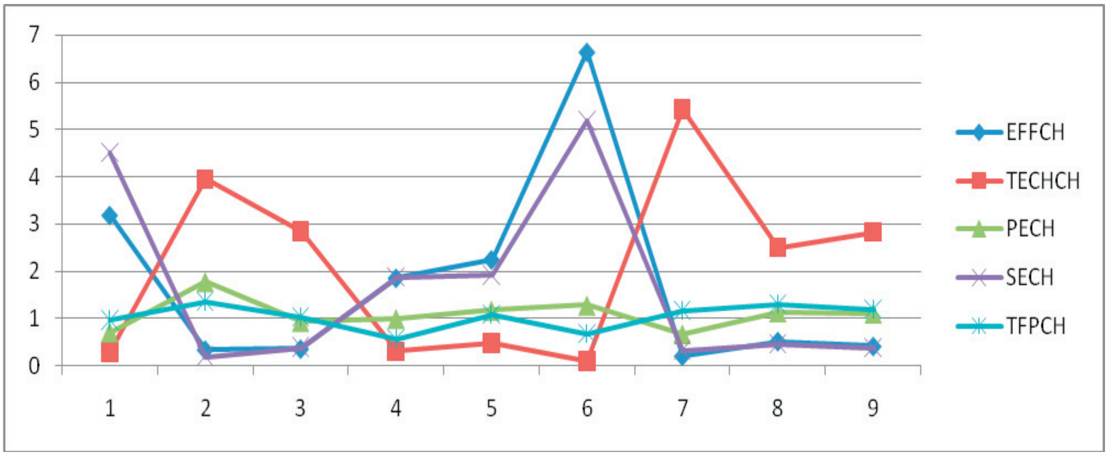

Fig. 1.Malmquist index values for period 2002-2010

In Fig. 1. can find a picture of the evolution of efficiency and productivity in the machinery industry in Romania in the period 2002-2010. From this figure we see that changing technical efficiency and scale efficiency changes recorded very low values in 2003, followed by accelerated growth until 2007. In years 2008-2010 values of these indices were also very small. An explanation of these variations can be attributed to the global economic crisis. A trend away from the two indices has presented the index of technological change. This can be considered normal because in critical situations enterprises resort to upgrade or improve the technology to be more efficient and productive. In terms of pure efficiency change index and total factor productivity index, they recorded similar values throughout the study, which means that reported to the inputs used and outputs resulted the machinery industry achieved a level of productivity almost constant.

4. Conclusion

In this paper, a nonparametric approach is used because it is less data demanding, to determine progress efficiency and changing productivity in machinery industry in Romania in period 2001-2010. After division by geographical areas the data showed that the industry recorded the largest increase in efficiency and productivity in the area S of Romania in the period. Analysing the Malmquist index values calculated on 27 companies in the period 2002-2010 we reached the conclusion that the machinery industry had a rising trend until 2007, followed by a sharp drop in 2008-2010 due to economic crisis.

The most recent style in measuring efficiency is data envelopment analysis, which is a linear program approach based on this concept. Data envelopment analysis measures the efficiency of decision making units by doing linear program for each comparing to other units. The decision making units can be made according to the frontier curve of efficiency in choosing the optimal mixture of inputs to achieve the aimed level of outputs. This approach is advocated in favour of the commonly used cross-sectional data analysis. The study has indicated how to use DEA approach to identify individual year that are less efficient to other comparable year in terms of output factors relative to input factors. The DEA Malmquist productivity approach shows that in-depth information can be obtained by analyzing each individual component of MPI. From the results of MPI, we know that industrial management not only enhance their managerial skills but also increase and improve innovative performance and upgrade technology level.

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